B. GULF OF MAINE-GEORGES BANK WHITE HAKE ASSESSMENT SUMMARY FOR 2012/13

State of Stock: White hake is not overfished and overfishing is not occurring, both with high certainty (Figure B1). Spawning stock biomass (SSB) in 2011 is estimated to be 26,877 mt which is 83% of the revised SSBMSY proxy (32,400 mt) (Figure B2). The 2011 fully selected fishing mortality is estimated to be 0.13 which is below (66% of) the revised FMSY proxy (0.20) (Figure B3). This stock status is a change from the previous stock assessment (see Special Comments).

Projections: Projection models were run sampling estimated age-1recruitment from a cumulative density function derived from agreed assessment model (ASAP) under two recruitment assumptions: the complete recruitment series between 1963 and 2009, and recent recruitment between 1995 and 2009, a period of lower recruitment. Recruitment estimates for 2010 and 2011 were not included in the re-sampling due to their greater variance. The catch scenarios were defined by the revised F_{MSY} and $75\%F_{MSY}$ proxies. The projections at $75\%F_{MSY}$ using the 1963-2009 time series of recruitment show SSB increasing from 28,886 mt in 2012 to 34,473 mt in 2015 and 35,371 mt in 2016, with the catches also increasing during this period (Table B1). Short term projections (2012-2016) were not greatly impacted by the recruitment assumption because these recruits do not fully enter the spawning stock or fishery by 2015. However, projected SSB increases to a lower level, peaking in 2015 and declining slightly in 2016 under the recent recruitment scenario. The SARC panel favored the recent recruitment scenario for short term projections (through 2016).

Catches: United States commercial landings of white hake averaged around 16,400 mt through the mid 1910s, then began declining to a low of 1,131 mt in 1967 (Figure B4). Landings then increased to a peak in 1985 of 7,351 mt followed by a secondary peak of 8,509 mt in 1992. United States landings have since declined both due to lower abundance and management measures implemented to reduce effort. Foreign landings have generally been low for this stock, ranging from no landings to 1,683 mt with an average of 362 mt. Discards averaged 1,256 mt in the 1960s, declined to about 900 mt in the 1970s, increased to 1,200 mt in the 1980s, and have declined to less than 200 mt since. Catch data are a source of uncertainty for this stock assessment, because of potentially mixed reported landings with red hake and uncertain identification to species by observers. Recreational catches averaged less than 12 mt and were imprecisely estimated, so are not included in the assessment.

Catch and Status Table (weights in mt): White Hake

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011		Max	Min	Mean
Landings														
US [1]	3,268	4,435	3,523	2,671	1,703	1,530	1,341	1,712	1,820	2,899		21,669	1,131	7,613
Foreign[2,3]	158	129	86	85	89	56	39	79	104	86		1,683	0	362
Total[2]	3,426	4,564	3,609	2,756	1,792	1,586	1,380	1,791	1,924	2,985		9,647	1,147	4,207
Discards[2]	123	324	113	93	62	36	171	83	91	54		1,896	36	768
Catch Used in Assessment[4]	3,547	4,879	3,720	2,828	1,853	1,621	1,545	1,872	2,014	3,039		10,666	1,545	4,958
Recreational[5]	10.70	9.50	11.30	6.20	7.90	1.60	11.00	3.90	6.10	12.70		106.40	0.00	11.33
SSB[6]	12,556	13,322	12,999	11,577	11,134	14,205	15,888	16,017	21,106	26,877		34,399	7,847	18,425
January 1 Biomass[6]	15,275	16,098	15,423	14,897	13,579	16,744	19,225	19,148	24,626	31,225		39,023	9,873	22,408
F[6]	0.35	0.46	0.35	0.31	0.19	0.13	0.12	0.14	0.11	0.13		1.07	0.11	0.35
Recruitment (000s of fish) [6]	2,506	2,458	2,296	3,841	4,946	4,047	5,053	5,672	5,898	4,006		13,072	2,296	5,439

[1]US Landings max, min, and mean based on 1893-2011.
[2]Foreign and total landings and discards max, min, and mean based on 1964-2011.
[3] Foreign landings are for NAFO Areas 5 and 6.
[4]Catch used in assessment is does not include recreational catch or catch of age-0 fish
[5] Recreational catch max, min, and mean based on 1981-2011.
[6] Assessment model results max, min, and mean based on 1963-2011.

Stock Distribution and Identification: White hake, *Urophycis tenuis*, is a demersal gadoid species distributed from the Newfoundland to North Carolina, and is most abundant in the Gulf of Maine (Bigelow and Schroeder 1953, Collette and Klein-McPhee 2002). White hake is managed as a single stock in United States waters. Based on a genetic study in Canadian waters, there is evidence for both population structure within and mixing among stock units (Roy *et al*. 2012). No such studies exist for white hake in US waters.

Data and Assessment: The 2013 assessment considered a wide range of data up to 2012, including state and federal surveys and commercial LPUE. The 2013 assessment model uses data from NEFSC surveys, vessel trip reports, dealer landings records and on-board fishery observers through 2011.

The previous assessment (GARM III, 2008) of Gulf of Maine-Georges Bank white hake was conducted using a statistical catch-at-age model (SCAA, also referred to as an age-structured production model, ASPM) that incorporated commercial landings and discards. In this 2013 SAW/SARC56 assessment, the model put forward by the white hake working group was a statistical catch-at-age model (ASAP) incorporating some formulations that differed from the GARM III SCAA model.

The 2013 assessment includes revised and updated catch estimates and minor changes to the strata used to compute the Northeast Fisheries Science Center (NEFSC) spring and autumn survey indices. The catch data in the previous assessment were derived using survey species proportions at length to split the combined red and white hake catch data into separate red and white hake catches. At the SAW/SARC 51 red hake assessment (NEFSC 2011), reported red hake landings and estimated discards were used, so to be consistent, the same approach is used for white hake. The revised catch had a larger impact on the assessment than revisions to the survey indices. The fishery age composition data from 1963-1981 were derived from a pooled

age-length key derived from the 1982-2004 (without 2003 for the fall) and 2011-2012 survey age data. Results from the SCAA and ASAP model formulations using the revised data were similar in trend and magnitude.

The 2013 model assumes two fishery selectivity time blocks instead of a single block as used in the previous assessment model based on model fits. The 2013 model assumes asymptotic selectivity at age for the catch whereas the previous model (NEFSC 2008) allowed domed selectivity at age for the catch and the NEFSC surveys, in each case based on the best fit to the data available at the time. All catch sources were combined into a single fleet. Estimates of abundance in numbers/tow from the NEFSC spring and autumn surveys (1963-2011) were used in the ASAP model along with associated estimates of variance and annual age composition. All changes in model configuration were informed by model diagnostics.

Biological Reference Points: There are a number of changes in the assessment model and data from the previous assessment, as shown below.

	GARM III (2008)	SARC 56
F_{MSY} proxy (F40%)	0.125 (on age 6)	0.20 (on age 6)
SSB/R	5.94	6.19
Mean Recruitment	8.0 million	5.5 million
SSB_{MSY} proxy	56,300 mt	32,400 mt
F pattern	Domed	Asymptotic at age 6
MSY	5,800 mt	5,630 mt

Based on the demographic and selectivity parameters of the white hake stock, the SPR based F reference point of F40% corresponds to fully selected F =0.20. The SARC panel recommended that F40% (i.e. fully selected F=0.20) remain as the proxy for F_{MSY}.
When the F_{MSY} value of 0.20 is used in long-term projections, including the full 1963-2009 recruitment time series, the estimate of SSB_{MSY} is 32,400 mt. The estimate of SSB in 2011 is 26,877 mt and fishing mortality in 2011 is 0.13.

Fishing Mortality: The estimates of fishing mortality were above F_{MSY} proxy at the start of the time series, declined to below F_{MSY} proxy during the 1970s, increased to more than 5 times the F_{MSY} proxy in the 1990s, but have been below the threshold since 2006 (Figure B3). The 2011 Ffull is estimated at 0.13 (90% posterior probability interval 0.11 – 0.16), well below the FMSY proxy =0.20 (Figure B3).

Biomass: The estimates of spawning stock biomass (SSB) have generally increased from a time series low of 7,850 in 1997 (Figure B2). SSB in 2011 is estimated to be 26,877 mt (90% posterior probability interval 23,127 – 30,729 mt). The spawning stock biomass is at 83% of the SSBMSY proxy=32,400 mt.

Recruitment: The time series mean recruitment (age 1) was 5.4 million. Strong year classes were produced in 1984, 1988 and 1989 (Figure B5). Mean recruitment between 1995 and 2009 was 3.8 million. Recent recruitments were near the time series average.

Special Comments:

- Estimated spawning stock biomass has increased from 14,205 mt in 2007 to 26,877 mt in 2011 in a period when F was low and recruitment has been near the long term average following a low period. This result is not due to a change in the model but reflects signals in the data. Landings have increased during this period as well.
- The SARC Panel notes that although recent recruitment has been sampled for reasons of short term projections, biological reference points were based on recruitments from the entire time series. There is no clear reason at this time to base reference points on a reduced time series of recruitment.
- The SAW Working Group (WG) recommended an F_{MSY} proxy of F35% based on simulations under fishing mortalities associated with F35% and F40%, indicating a central tendency for risk that SSB would be reduced below 20% of virgin biomass of less than 5%. The WG chose F35% on the basis that there was little difference in risk for F35% and F40% and F35% offered higher yield opportunities. Upon further review of the risk, the SARC Panel identified a greater difference in risk levels between the reference points than originally indicated by the WG. Risk increased steeply as F was increased from F40% to F35% and as stock-recruitment steepness was decreased from h=0.8 to h=0.7. Consequently, the SARC Panel recommended that in the absence of more detailed investigation of stock-recruitment dynamics and associated risk levels, the F_{MSY} proxy of F40% currently in place should remain.

References:

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Fish and Wildl. Serv., Fish. Bull. 74: 223-230 p.

Collette BB, Klein-MacPhee G. 2002. Bigelow and Schroeder's fishes of the Gulf of Maine, 3rd ed. Smithsonian Institution Press. Washington D.C.

NEFSC (Northeast Fisheries Science Center). 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 08-15: 884 p + xvii.

NEFSC (Northeast Fisheries Science Center). 2011. 51st Northeast Regional Stock Assessment Workshop (51st SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-02: 856 p.

Roy D, Hurlbut TR. 2012. Biocomplexity in a demersal exploited fish, white hake (*Urophycis tenuis*): depth-related structure and inadequacy of current management approaches. Can. J. Fish. Aquat. Sci. 69(3): 415-429.

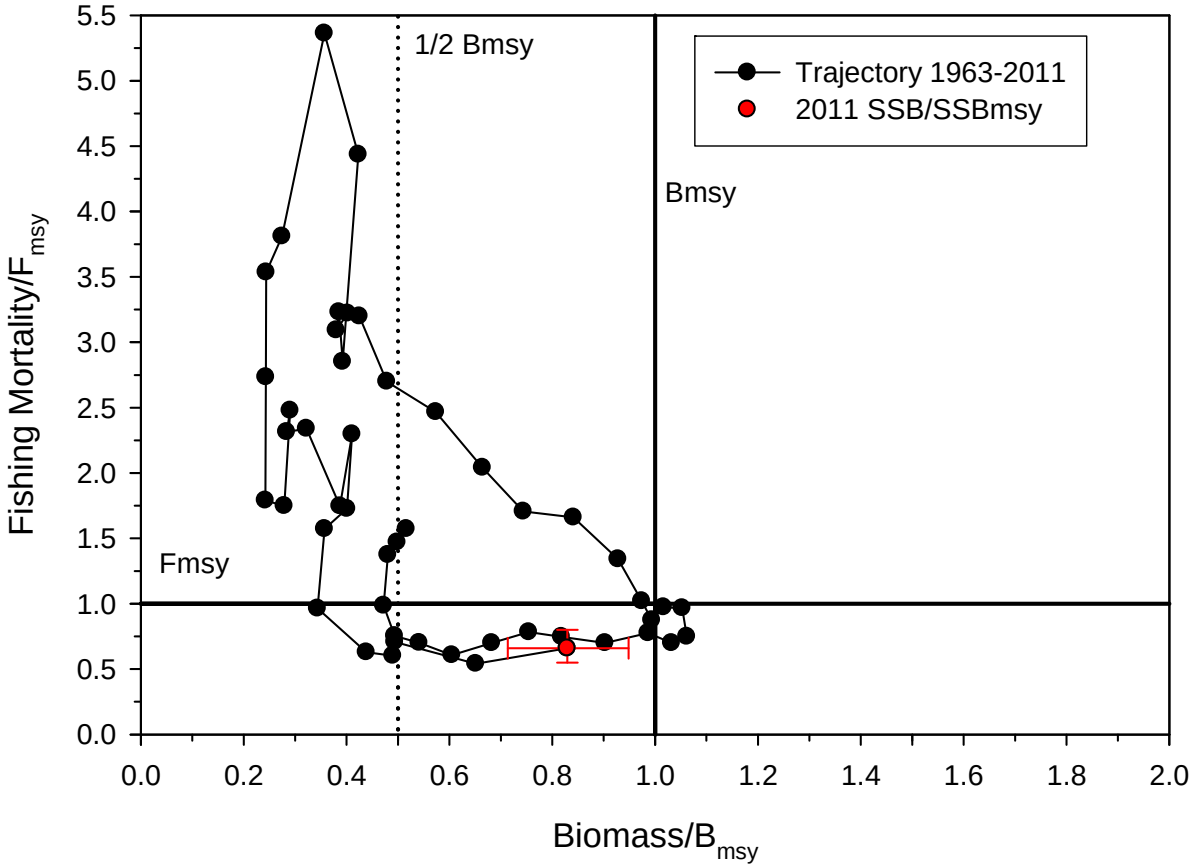
Table B1. Short term projections of total fishery yield and spawning stock biomass for Gulf of Maine-Georges Bank white hake based on a harvest scenario of fishing at 75% FMSY between 2013 and 2015. Catch in 2012 has been estimated at 2,900 mt

Long Time Series of Recruitment (1963-2009)

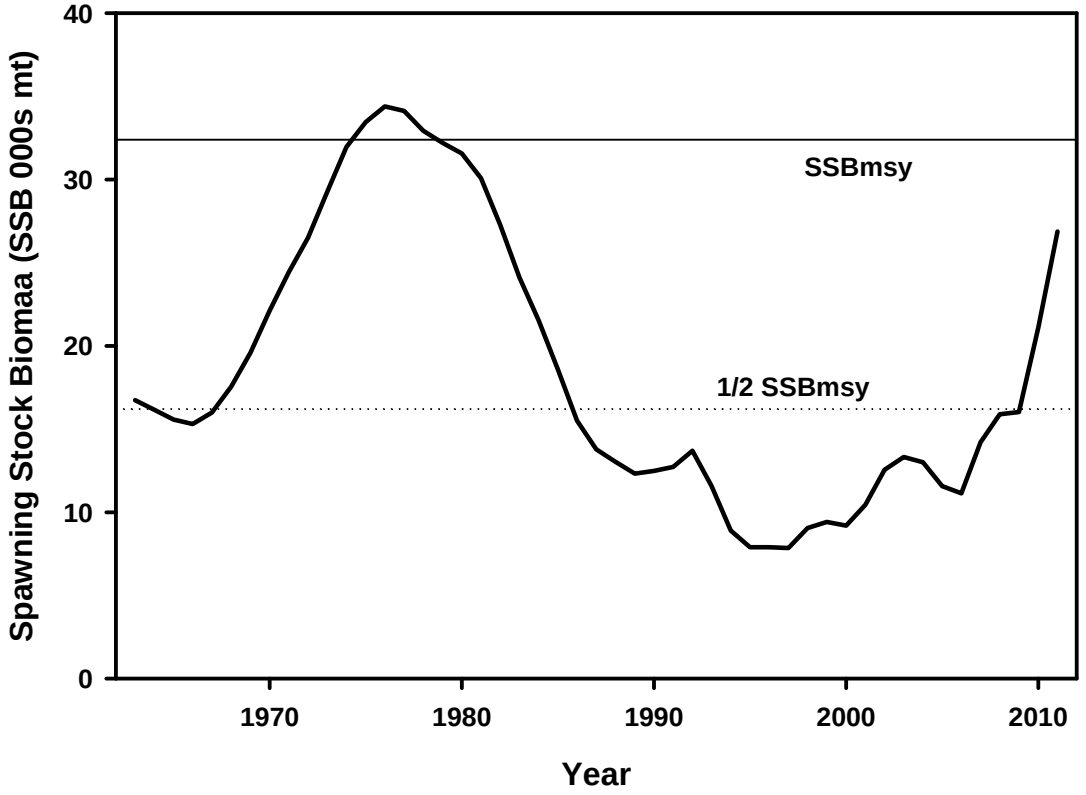
Year	Catch	5%	95%	SSB	5%	95%	F
2012	2,900	-	-	28,886	24,659	33,166	0.12
2013	4,181	3,313	5,205	31,999	27,297	37,095	0.15
2014	4,450	3,566	5,567	33,656	28,911	39,175	0.15
2015	4,595	3,704	5,742	34,473	29,952	39,951	0.15
2016	4,668	3,803	5,830	35,371	30,641	41,248	0.15

Short Time Series of Recruitment (1995-2009)

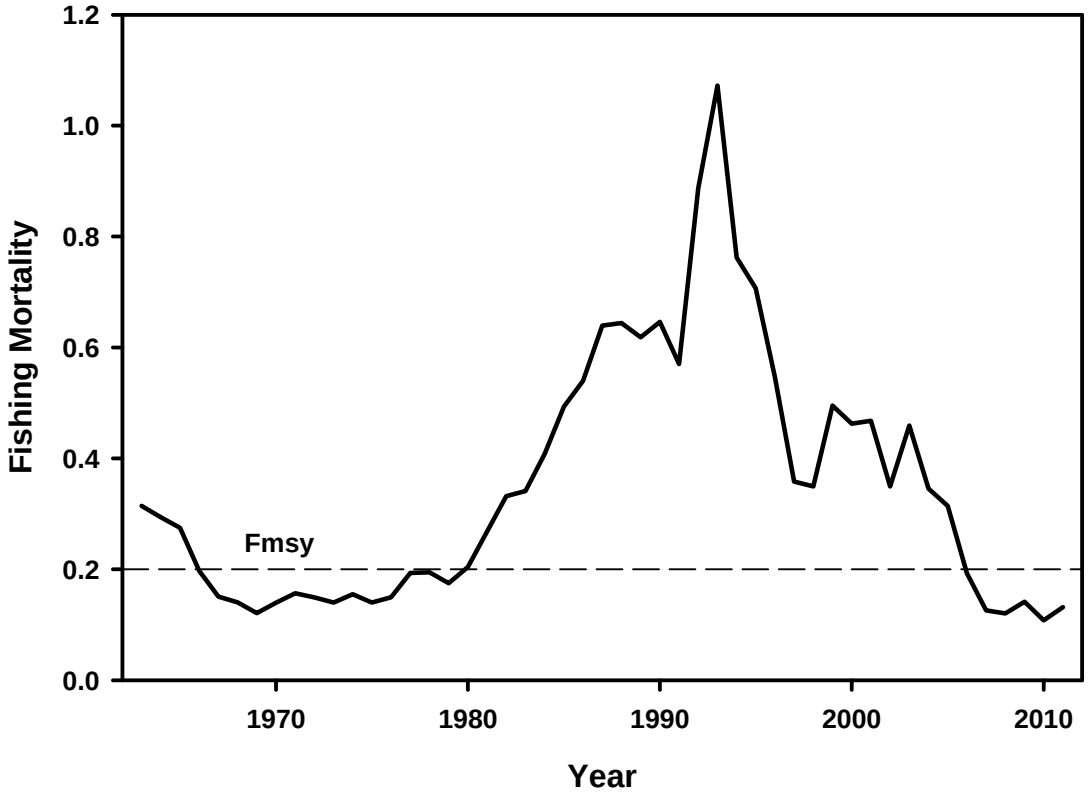
Year	Catch	5%	95%	SSB	5%	95%	F
2012	2,900	-	-	28,886	24,659	33,166	0.12
2013	4,177	3,552	4,823	31,986	27,255	37,085	0.15
2014	4,435	3,796	5,137	33,559	28,765	39,087	0.15
2015	4,532	3,929	5,266	33,893	29,505	39,269	0.15
2016	4,490	3,919	5,193	33,683	29,521	38,663	0.15



B1. Stock status of Gulf of Maine-Georges Bank white hake for 2011 relative to F40% proxy MSY reference points for spawning stock biomass (SSB) and fishing mortality (FFull); 2011 estimate is the colored dot, error bars represent 90% posterior probability intervals. Dotted line is the 1963-2010 time series ratio of SSB to SSB_{MSY} based on 2012 MSY reference points.

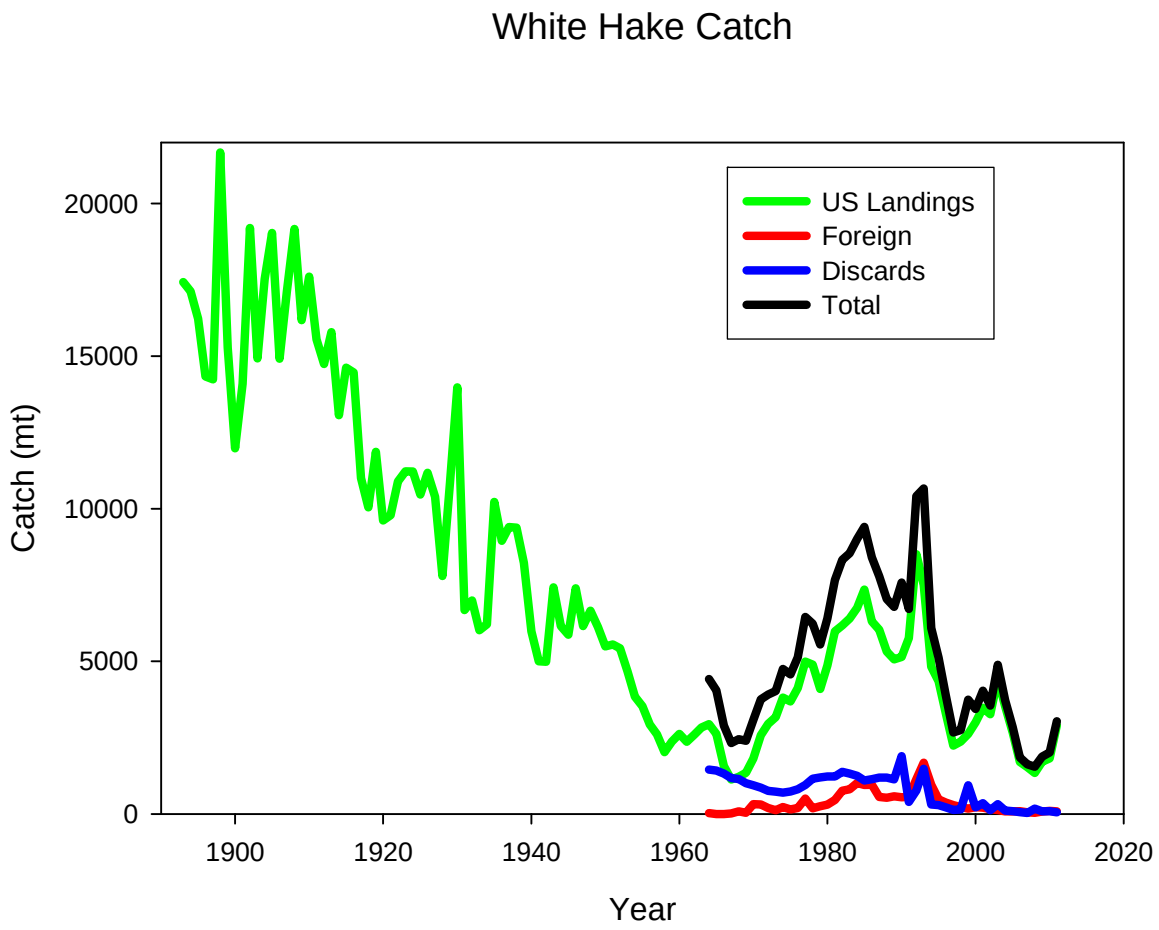


B2. Estimated trends in the spawning stock biomass of Gulf of Maine-Georges Bank white hake between 1963 and 2011 and the corresponding SSB_{target} (SSBMSY) and SSBthreshold (1/2 SSBMSY) based on the 2013 assessment using F40%.

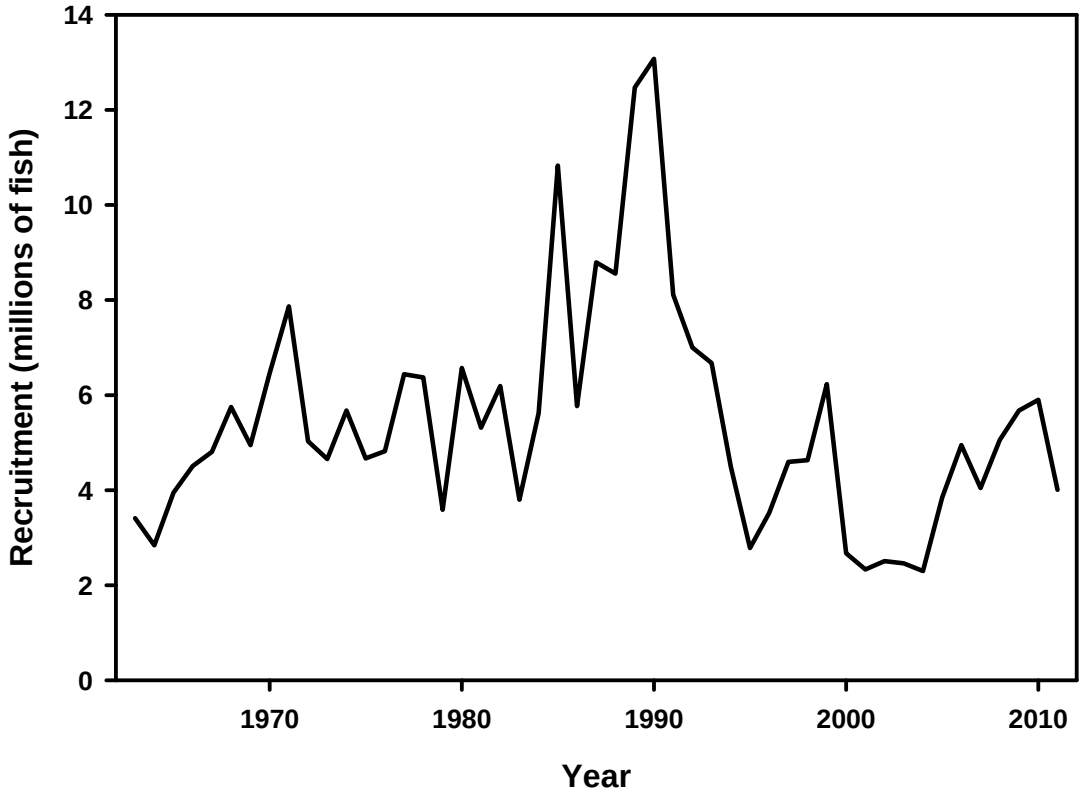


B3. Estimated trends in the fully selected fishing mortality (Ffull) of Gulf of Maine-George Bank white hake between 1963 and 2011, and the corresponding FMSY (F40%) based on the 2013 assessment.

**Note that the time series includes two selectivity blocks (1963-1997, 1998-2011) and the Ffull values are not comparable between blocks.*



B4. Catches of Gulf of Maine-Georges Bank white hake from 1893-2011. The green line is United States landings back to 1893. The blue line is United States discards and the red line is foreign landings. The black line (on top) is the total catch from 1964-2011.



B5. The time series of mean Gulf of Maine-Georges Bank white hake recruitment at age 1.